BS EN 60794-1-21:2015+A1:2020

BSI Standards Publication

Optical fibre cables

Part 1-21: Generic specification — Basic optical cable test procedures — Mechanical tests methods

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Full document details: BS EN 60794-1-21:2015+A1:2020

National foreword

This British Standard is the UK implementation of EN 60794-1-21:2015+A1:2020. It is identical to IEC 60794-1-21:2015, incorporating amendment 1:2020. It supersedes BS EN 60794-1-21:2015, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee GEL/86/1, Optical fibres and cables.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Amendments/corrigenda issued since publication

Date	Text affected
31 May 2020	Implementation of IEC amendment 1:2020 with CENELEC endorsement A1:2020

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NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60794-1-21:2015+A1

April 2020

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English Version

Optical fibre cables - Part 1-21: Generic specification - Basic optical cable test procedures - Mechanical tests methods (IEC 60794-1-21:2015)

Câbles à fibres optiques - Partie 1-21: Spécification générique - Procédures fondamentales d'essais des câbles optiques - Méthodes d'essai mécanique
(IEC 60794-1-21:2015)

Lichtwellenleiter - Teil 1-21: Fachgrundspezifikation - Grundlegende - Prüfverfahren für Lichtwellenleiterkabel - Mechanische Prüfverfahren
(IEC 60794-1-21:2015)

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European foreword

The text of document 86A/1638/FDIS, future edition 1 of IEC 60794-1-21, prepared by SC 86A "Fibres and cables" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60794-1-21:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2016-01-14
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-04-14

This document supersedes EN 60794-1-2:2003 (partially).

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The text of the International Standard IEC 60794-1-21:2015 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 86A/1975/FDIS, future IEC 60794-1-21/A1, prepared by SC 86A "Fibres and cables" of IEC/TC 86 "Fibre optics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60794-1-21:2015/A1:2020.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2021-01-09
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2023-04-09

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In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60794-1-23	NOTE	Harmonized as EN IEC 60794-1-23
IEC 61395	NOTE	Harmonized as EN 61395

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60227-2	-	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V -- Part 2: Test methods	-	-
IEC 60793-1-22	2001	Optical fibres -- Part 1-22: Measurement methods and test procedures - Length measurement	EN 60793-1-22	2002
IEC 60793-1-32	2010	Optical fibres -- Part 1-32: Measurement methods and test procedures - Coating strippability	EN 60793-1-32	2010
IEC 60793-1-40	-	Optical fibres -- Part 1-40: Measurement methods and test procedures - Attenuation	EN 60793-1-40	-
IEC 60793-1-46	2001	Optical fibres -- Part 1-46: Measurement methods and test procedures - Monitoring of changes in optical transmittance	EN 60793-1-46	2002
IEC 60794-1-1	-	Optical fibre cables -- Part 1-1: Generic specification - General	EN 60794-1-1	-
IEC 60794-1-2	2013	Optical fibre cables -- Part 1-2: Generic specification - Cross reference table for optical cable test procedures	EN 60794-1-2	2014
IEC 60794-1-20	2014	Optical fibre cables -- Part 1-20: Generic specification - Basic optical cable test procedures - General and Definitions	EN 60794-1-20	2014
IEC 60794-1-22	2012	Optical fibre cables -- Part 1-22: Generic specification - Basic optical cable test procedures - Environmental test methods	EN 60794-1-22	2012
IEC 61300-2-44	-	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 2-44: Tests - Flexing of the strain relief of fibre optic devices	EN 61300-2-44	-
IEC/TR 62691	-	Optical fibre cables - Guide to the installation of optical fibre cables	-	-

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OPTICAL FIBRE CABLES –

Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical test methods

FOREWORD

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International Standard IEC 60794-1-21 has been prepared by subcommittee 86A: Fibres and cables, of IEC technical committee 86: Fibre optics.

This first edition of IEC 60794-1-21 cancels and replaces the mechanical tests part of the second edition of IEC 60794-1-2, published in 2003. It constitutes a technical revision.

It has been decided to split the second edition of IEC 60794-1-2 into six new documents:

– IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*
– IEC 60794-1-20, *Optical fibre cables – Part 1-20: Generic specification – Basic optical cable test procedures – General and definitions*

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– IEC 60794-1-21, *Optical fibre cables – Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical tests methods*
– IEC 60794-1-22, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental tests methods*
– IEC 60794-1-23, *Optical fibre cables – Part 1-23: Generic specification – Basic optical cable test procedures – Cable elements tests methods*
– IEC 60794-1-24, *Optical fibre cables – Part 1-24: Generic specification – Basic optical cable test procedures – Electrical tests methods*

The text of this standard is based on the following documents:

FDIS	Report on voting
86A/1638/FDIS	86A/1655/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This standard is intended to be used in conjunction with IEC 60794-1-1.

A list of all parts in the IEC 60794 series, published under the general title *Optical fibre cables*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION to Amendment

This Amendment adds new test methods and revises existing ones in a timely fashion until the next full revision of IEC 60794-1-21:2015.

Both the E-series numbering of the test methods, clause numbers, figures and equations of the technical section are aligned with IEC 60794-1-21:2015.

As part of the ongoing rationalization of the test methods specification set, several tests of IEC 60794-1-21 were determined to be more properly aligned with others of the set and have been moved. To that end, the proposed text to affect these moves has been inserted in this document.

Clause 7 has been redesignated as a cable element test method. It has been moved to IEC 60794-1-23 Ed2 and given the test method number G10A.

Clause 8 has been redesignated as a cable element test method. It has been moved to IEC 60794-1-23 Ed2 and given the test method number G10B.

Clause 18 has been redesignated as an environmental test method. It has been moved to IEC 60794-1-22 Ed2 and given the test method number F16.

Clause 19 has been redesignated as a cable element test method. It has been moved to IEC 60794-1-23 Ed2 and given the test method number G9.

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OPTICAL FIBRE CABLES –

Part 1-21: Generic specification – Basic optical cable test procedures – Mechanical test methods

1 Scope and object

This part of IEC 60794 applies to optical fibre cables for use with telecommunication equipment and devices employing similar techniques, and to cables having a combination of both optical fibres and electrical conductors.

The object of this standard is to define test procedures to be used in establishing uniform requirements for mechanical requirement performance.

Throughout this standard the wording “optical cable” may also include optical fibre units, microduct fibre units, etc.

〈A1〉 See IEC 60794-1-2 for general requirements and definitions and for a complete reference guide to test methods of all types. 〈A1〉

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60227-2, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*

IEC 60793-1-22:2001, *Optical fibres – Part 1-22: Measurement methods and test procedures – Length measurement*

IEC 60793-1-32:2010, *Optical fibres – Part 1-32: Measurement methods and test procedures – Coating strippability*

IEC 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-46:2001, *Optical fibres – Part 1-46: Measurement methods and test procedures – Monitoring of changes in optical transmittance*

IEC 60794-1-1, *Optical fibres – Part 1-1: Generic specification – General*

IEC 60794-1-2:2013, *Optical fibre cables – Part 1-2: Generic specification – Cross reference table for optical cable test procedures*

IEC 60794-1-20:2014, *Optical fibre cables – Part 1-20: Generic specification – Basic optical cable test procedures – General and definitions*

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IEC 60794-1-22:2012, *Optical fibre cables – Part 1-22: Generic specification – Basic optical cable test procedures – Environmental test methods*

IEC TR 62691, *Guide to the installation of optical fibre cables*

IEC 61300-2-44, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-44: Tests – Flexing of the strain relief of fibre optic devices*

3 Method E1: Tensile performance

3.1 Object

This test method applies to optical fibre cables which are tested at a particular tensile strength in order to examine the behaviour of the attenuation and/or the fibre elongation strain as a function of the load on a cable which may occur during installation and operation. This method is intended to be non-destructive.

3.2 Sample length

Length under tension ≥ 50 m unless otherwise defined in the relevant specification. For cables requiring specialized anchoring devices (e.g. OPGW, all-dielectric self-supporting (ADSS), heavy wire armored cables, etc.), the minimum length shall be 25 m.

Short lengths in the tensile test will adversely affect the accuracy of the measurement. The lengths shown above are the recommended minimum lengths for this test.

Total sample length is longer than the length under tension to allow for clamping and connection to test equipment.

3.3 Apparatus

The apparatus consists of

a) an attenuation measuring apparatus for the determination of attenuation changes (see IEC 60793-1-40), and/or a fibre elongation strain measuring apparatus (see IEC 60793_1_22:2001, Method C: Fibre elongation);

b) a tensile strength measuring apparatus which is able to accommodate the minimum length to be tested. Transfer devices may be used for testing longer samples under tension (see Figure 2). The diameters of sheaves in the transfer device shall be no smaller than the minimum bending diameter of the cable under test; typically 1 m diameter;

c) a load cell with a maximum error of ±3 % of its maximum range;

d) a clamping device to secure all cable components at the ends of the length under test: care should be taken that the specific method of capturing the cable components does not affect the results. A mandrel is frequently an appropriate device, with a diameter typically 1 m, but not less than the minimum bending diameter specified for the cable;

e) if required, mechanical or electrical means for measuring the cable load or elongation, per the detail specification shall be provided.

Examples of suitable apparatus are shown in Figure 1 and Figure 2.

3.4 Procedure

3.4.1 General requirements

a) Unless otherwise specified, the conditions for testing shall be in accordance with the expanded test conditions as defined in IEC 60794-1-20.

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b) Load the cable onto the tensile rig and secure it. At both ends of the tensile rig, a method of securing the cable shall be used, which uniformly locks the cable so that all components of the cable, including fibres, are restricted in their movement. For most cable constructions (e.g. stranded type cables), clamping on cable elements, except the fibres, is practical and sufficient to obtain attenuation changes and/or both the maximum allowable pulling load and the strain margin of the cable. However, for certain cable constructions (e.g. single loose tube), it may be necessary to prevent the fibres from slipping in order to obtain the correct strain margin figures.

For aerial cable types, if required by the detail specification, the fixing of the cable may be made by means of the anchoring devices relevant to the type of cable considered. For certain heavily armoured cables, a clamping device involving a stocking grip or similar anchoring device may be used.

c) Connect the test fibre of the cable under tensile test to the measurement apparatus. For the pulse delay (time of flight) technique of Method C of IEC 60793-1-22:2001, care shall be taken that, during the pulling of the sample, the reference length does not change.

d) The tension shall be continuously increased to the required value(s) given in the relevant specification.

e) The change of attenuation and/or fibre strain shall be recorded, as a function of cable load or elongation.

f) For cables with a large number of fibres, a multiple attenuation and/or fibre strain measuring device can be used.

g) A representative number of fibres and/or a number of test cycles (typically one) shall be agreed between manufacturer and customer.

h) The readings taken at the end of the time periods stated in 3.4.2 should be stable (i.e within measurement uncertainty) before the loads are changed or the test completed. If the readings are still fluctuating then the load holding period should be extended until they are stable.

3.4.2 Procedure

Measure the optical attenuation and/or determine the fibre strain before the start of the test as a baseline:

a) apply the short-term load to the cable;

b) hold this load for 10 min;

c) determine fibre strain, if required;

d) if required, change the applied load to the long term load

- hold this load for 10 min,
- measure the attenuation and/or determine the fibre strain;

e) remove the load;

f) allow the cable to rest for 5 min;

g) measure the attenuation and/or determine the fibre strain.

Different steps and load levels can be used if agreed between customer and supplier.

3.5 Requirements

The attenuation change and/or fibre strain of the sample shall not exceed the values given in the relevant specification.

3.6 Details to be specified

The relevant specification shall include the following:

– length under tension if different from this method;

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– T_L long term load: load applied, limits on fibre strain, and/or change of attenuation;
– T_S short term load: load applied, limits on fibre strain (if required);
– $T_{\text{after the test}}$: limits on fibre strain and/or change in attenuation.

3.7 Details to be reported

Values for all attributes from 3.6 shall be reported plus the following:

– end preparation;
– rate of tension increase;
– temperature, if different from that indicated for standard test conditions.

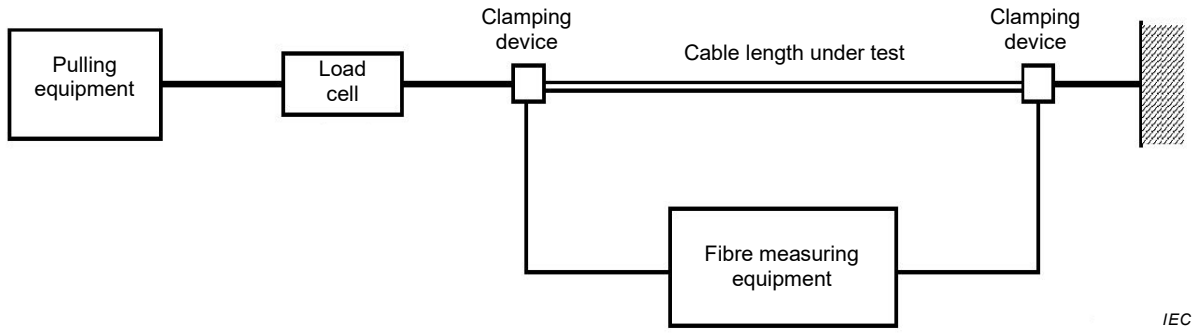

Figure 1 – Tensile performance measuring apparatus

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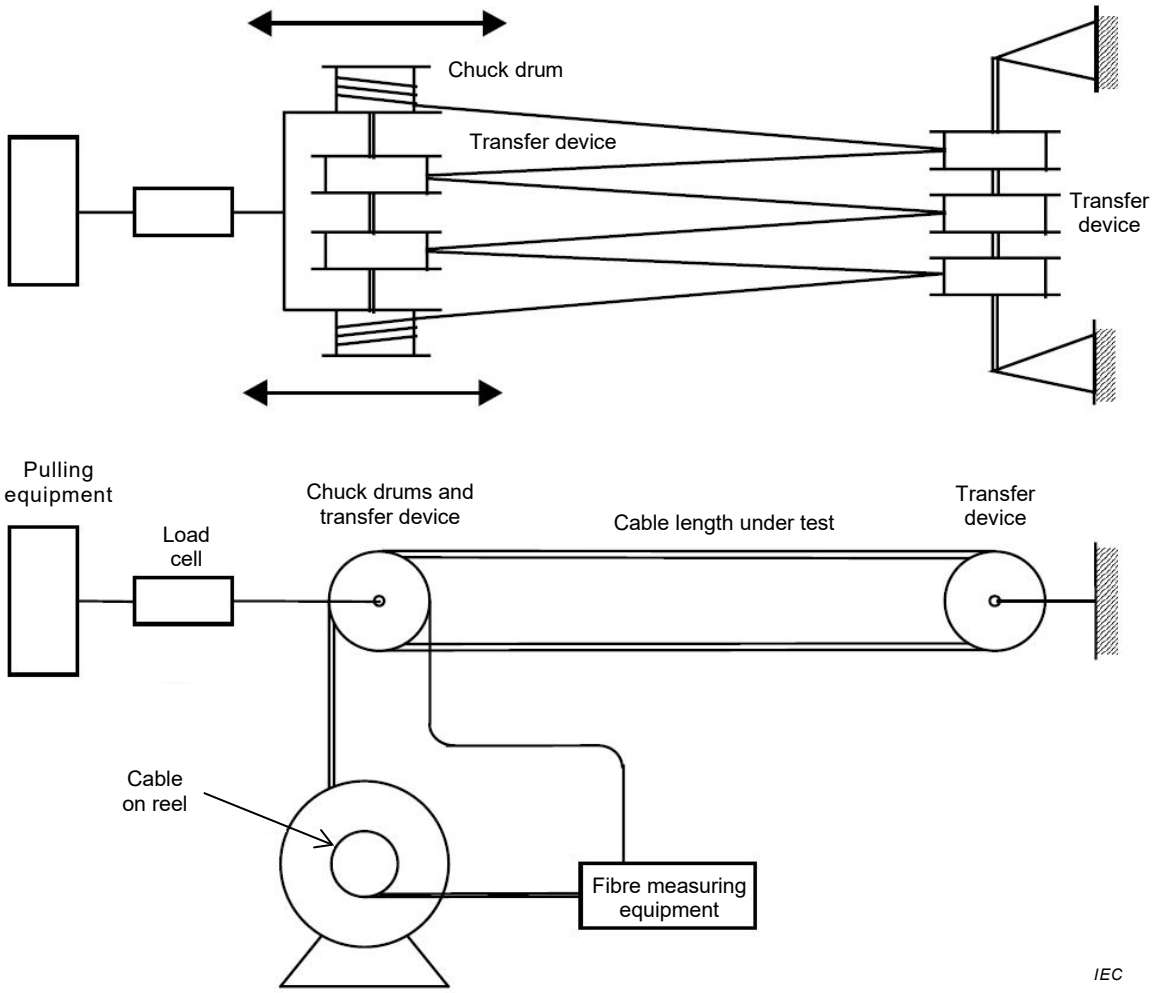

Figure 2 – Example of tensile performance measuring apparatus using transfer devices and chuck drums

4 Method E2: Abrasion

4.1 Object

The abrasion resistance of optical fibre cables has two aspects:

a) the ability of the sheath to resist abrasion, E2A;

b) the ability of cable markings to resist abrasion, E2B.

The purpose of this test is to determine the ability of an optical fibre cable sheath or sheath markings to resist abrasion.

4.2 Sample

The sample shall be of a length sufficient to carry out the specified test. A typical length is 750 mm.

4.3 Method E2A: Abrasion resistance of optical fibre cable sheaths

4.3.1 Apparatus

The abrasion test rig consists of a device designed to abrade the surface of the cable in both directions parallel to the longitudinal axis of the cable over a length of (40 ± 1) mm at a

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frequency of (55 ± 5) cycles/min. One cycle consists of one abrading edge movement in each direction.

The abrading edge shall be a steel needle with a diameter of 1,0 mm or as specified in the detail specification

A typical apparatus is shown in Figure 3.

4.3.2 Procedure

The following steps shall be taken:

a) Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions, as defined in IEC 60794-1-20.

b) Securely attach the cable sample to the supporting plate by means of cable clamps. The abrading edge shall be loaded with 4 N whilst avoiding shock to the cable. The initial position shall be such that there is length available for the subsequent movement of the sample, per c) below.

c) Four tests shall be made on the sample, with the sample moved forward 100 mm between tests and rotated through an angle of 90°, always in the same direction.

4.3.3 Requirements

There shall be no perforation of the sheath after performing the number of cycles specified in the detail specification.

4.3.4 Details to be specified

The detail specification shall include the following:

a) number of cycles;

b) force applied if other than specified herein; and

c) diameter of needle if other than specified herein.

4.4 Method E2B: Abrasion resistance of optical fibre cable markings

4.4.1 Apparatus

4.4.1.1 Method 1

As specified in E2A.

4.4.1.2 Method 2

The apparatus follows the intent of that specified in E2A and in E2B, Method 1, with the needle replaced by a wiping felt. The following changes are made in the apparatus:

a) a test set-up, to apply a force to the wool felt. A typical example is shown in Figure 4;

b) a wool felt, colour white;

NOTE Common felts are a blend of wool and other fibres, commonly rayon. Blends from 100 % to 30 % wool, or as specified by the relevant specification, meet the purpose of this method.

c) masses to apply a force to the sample;

d) the apparatus shall allow a stroke length of 100 mm at a frequency of 6 to 12 cycles/min.

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4.4.2 Procedure

4.4.2.1 General

Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.

4.4.2.2 Method 1

As specified in E2A, but all four tests shall be made on the cable marking.

4.4.2.3 Method 2

A sample of cable containing markings shall be laid between the two parts of the wool felt or between the wool felt and a supporting surface. In either case, the wool felt shall wipe the printed section of the cable.

The wool felt shall be thoroughly impregnated with water.

The normal force (F) of 5 N (or as given in the detail specification) shall be applied to the markings on the sample which is moved back and forth over a length of 100 mm. The number of cycles shall be specified in the detail specification.

4.4.3 Requirements

The marking shall be legible at the completion of the test after the number of cycles specified in the detail specification.

4.4.4 Details to be specified

The detail specification shall include the following:

a) number of cycles;
b) method used;
c) force applied if other than specified herein.

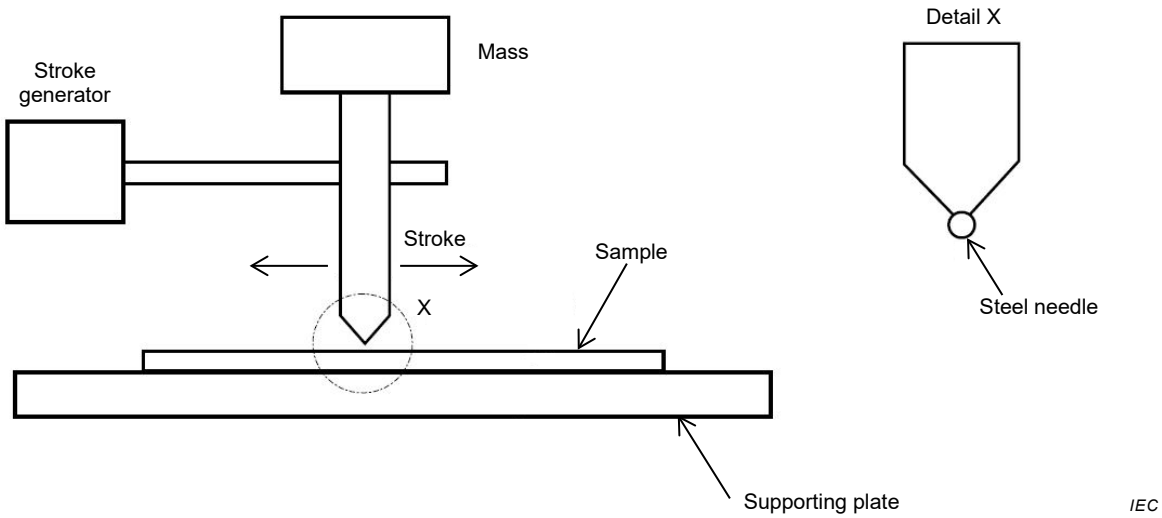

Figure 3 – Typical test set-up for tests E2A and E2B method 1

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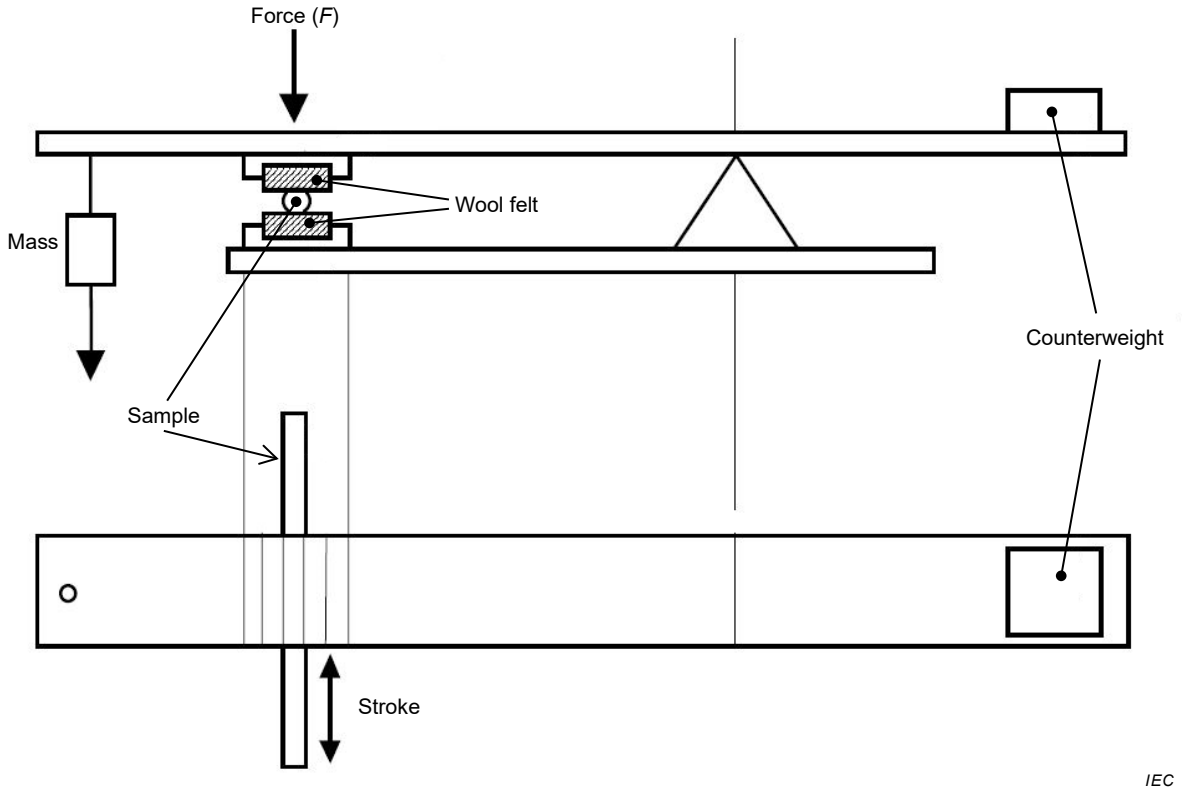

Figure 4 – Typical test set-up for test E2B, apparatus 2

5 Method E3: Crush

5.1 Object

The purpose of this test is to determine the ability of an optical fibre cable to withstand crushing for long term and for short-term loads.

NOTE Method E3A corresponds to the default method, Method E3 Crush, defined in IEC 60794-1-2:2013.

5.2 Sample

The sample shall be of a length sufficient to carry out the specified test.

5.3 Method E3A: Plate/plate

5.3.1 Apparatus

The apparatus shall allow a sample of cable to be crushed between a flat steel base plate and a movable steel plate which applies the crushing force uniformly over a 100 mm length of the sample.

The edges of the movable plate shall be rounded with a radius of about 5 mm. The edges are not included in the 100 mm flat part of the plate. A suitable apparatus is shown in Figure 5.

5.3.2 Procedure

The cable sample shall be mounted between the plates so that lateral movement is prevented, and the force shall be applied gradually without any abrupt change. If the force is applied in incremental steps, these shall not exceed a ratio of 1,5:1.

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The force shall be maintained stable at the specified test value at a specified time. This time is typically 1 min (short-term) or 10 min (long-term) if not specified in the detail specification. Attenuation measurement shall be performed before the force is released.

Unless otherwise specified in the detail specification, the test shall be performed three times, the force being applied on the specimen at three different places, without rotating the cable. The distance between each crush shall be not less than 500 mm apart and different from the lay length of the cable core.

Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.

5.4 Method E3B: Mandrel/plate

5.4.1 Apparatus

The same apparatus as for Method E3A shall be used, but a steel mandrel with a diameter of 25 mm (unless otherwise specified in the detail specification) is inserted perpendicular to the sample or replaces the movable plate in Figure 6.

5.4.2 Procedure

The procedure is the same as for Method E3A but a steel mandrel with a diameter of 25 mm (unless otherwise specified in the detail specification) is inserted perpendicular to the sample.

5.5 Requirements

The acceptance criteria for the test shall be as stated in the detail specification. Typical failure modes include loss of optical continuity, degradation of optical transmittance or physical damage to the cable.

NOTE Imprints or scratches on sheath and cable elements are not regarded as a failure.

5.6 Details to be specified

The detail specification shall include the following:

a) total force applied, *F*;
b) duration of application of the force;
c) number of tests;
d) spacing between test places;
e) configuration of mandrel, if used;
f) maximum allowable change in optical transmittance for short- and long-term load during and after the test.

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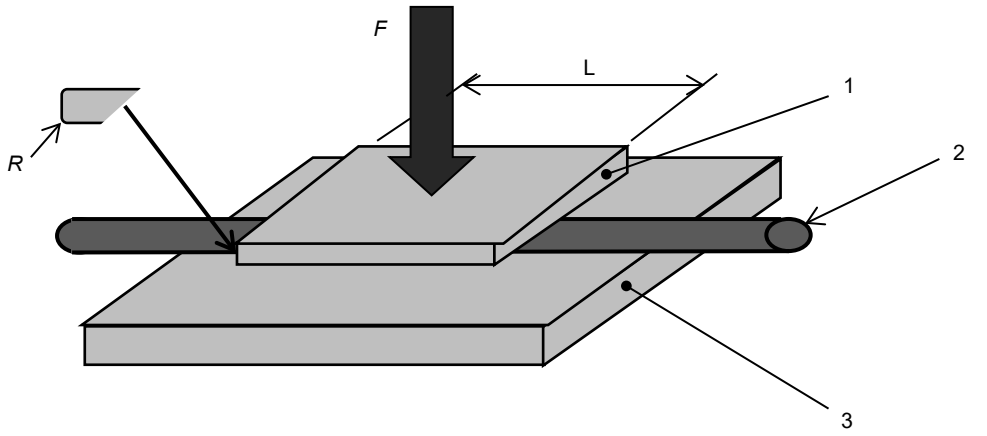

Key

R radius of edge of movable plate, 5 mm

F force on movable place, as defined in relevant specification

L length of plate, 100 mm

1 movable plate

2 cable under test

3 fixed plate

Figure 5 – Apparatus for crush test, Method E3A, details of plate/plate option

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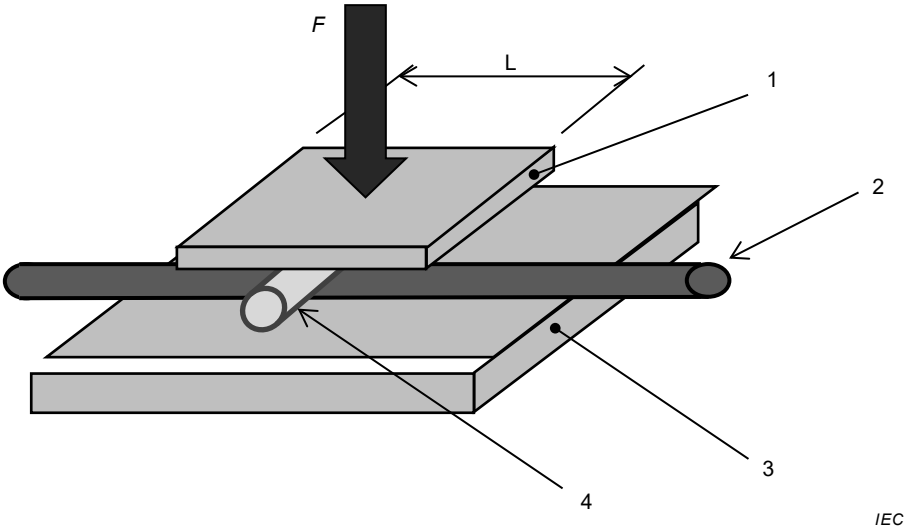

Key

F force on movable place, as defined in relevant specification

L length of plate, 100 mm

1 movable plate

2 cable under test

3 fixed plate

4 mandrel (cylinder or half-cylinder), 25 mm diameter

Figure 6 – Apparatus for crush test, Method E3B, details of plate/mandrel option

6 Method E4: Impact

6.1 Object

The purpose of this test is to determine the ability of an optical fibre cable to withstand impact.

6.2 Sample

6.2.1 Sample length

The sample length shall be sufficient to carry out the specified test. When only physical damage is to be evaluated, the length may range from 1 m (for example for small diameter jumper cords or duplex cables) to 5 m (for larger diameter cables). Longer lengths may be necessary to permit optical measurements.

6.2.2 Termination

The sample shall be terminated at each end in a connector, or in a manner such that the fibres, sheathings and any strain members are clamped together in a representative manner. Clamps on the impact apparatus may be used, or the sample may be long enough so that no restraint is needed.

6.3 Apparatus

The apparatus shall allow an impact to be imparted to the cable sample which is fixed to a flat substantial steel base. When a single or only a few impacts are required, a suitable apparatus, as shown in Figure 7a, is used. This allows a weight to drop vertically onto a piece of steel which transmits the impact to the cable sample. When repeated impacts are required (say, more than five), a more practical apparatus, as shown in Figure 7b, is used, which allows multiple

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impacts by a drop hammer. The apparatus shall be arranged to impart minimal friction to the moving weight/hammer.

NOTE This issue of friction has been found to be a particular problem when the apparatus is used at temperature extremes.

In both cases, other equivalent apparatus may also be used.

The striking surface shall either be flat or have a curved surface with curvature radius of no less than 300 mm. If using a flat striking surface, the edges of the face shall be radiused to avoid a stress concentration riser, Figure 7c, detail B. If using a 300 mm curvature radius striking surface, then the surface may also be a spherical segment, as shown in Figure 7c, detail A, since for such a large curvature radius this gives an equivalent test method to that when using a rounded cylinder,.

The radius on the edge on the flat striking surface and on the 300 mm curvature radius striking surface shall be approximately 0,5 mm.

The apparatus shall include any optical test equipment needed to measure the changes in optical performance as required in the detail specification, and specified in Method A (Transmitted power) of IEC 60793-1-46:2001.

6.4 Procedure

Unless otherwise specified, the conditions for testing shall be in accordance with standard atmospheric conditions.

The mass of the weight or drop hammer and the height from which it falls shall be adjusted to give the value of impact energy shown in the detail specification. The number and rate of impacts, and their location on the sample shall be as specified in the detail specification.

6.5 Requirements

The acceptance criteria for the test shall be as stated in the detail specification. Typical failure modes include loss of optical continuity, degradation of optical transmittance or physical damage to the cable.

6.6 Details to be specified

The detail specification shall include the following:

a) number of impacts;
b) impact energy;
c) test temperature;
d) radius of the striking surface if other than specified herein;
e) frequency of multiple impacts (if any);
f) location of impacts on the sample;
g) if optical continuity or change in transmittance is to be measured.

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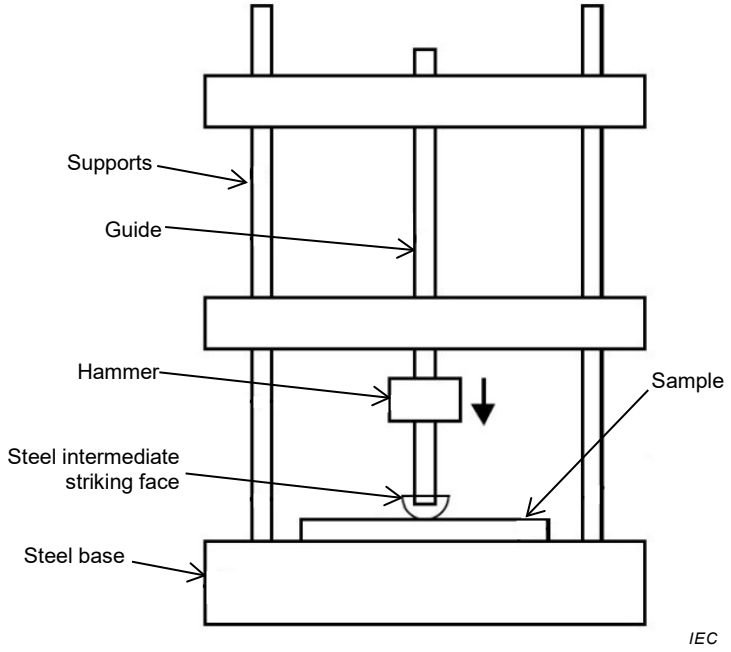

Figure 7a – Impact test – Apparatus for a few impacts

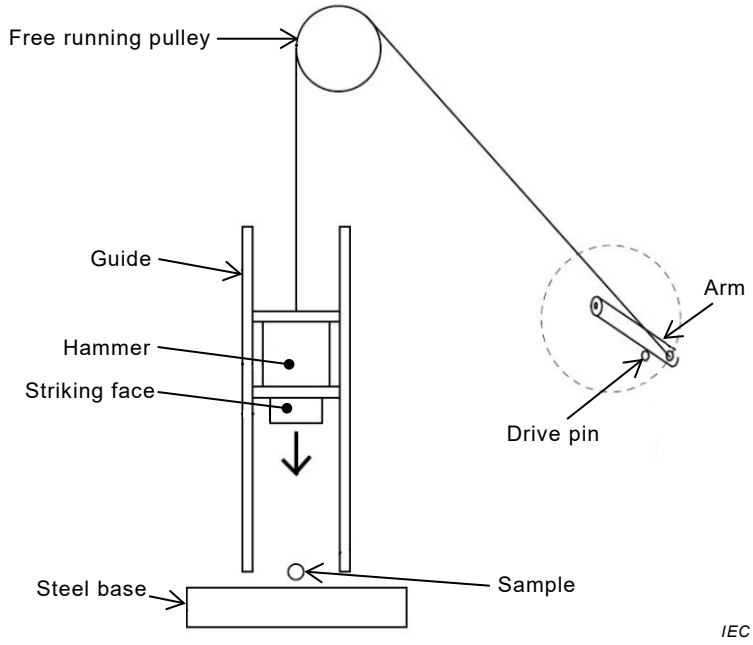

Figure 7b – Impact test – Apparatus for multiple impacts

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